Mark schemes

1

(a) decrease

for 1 mark

1

(b) (i) none would go through paper

for 1 mark

1

(ii) all would go through paper

for 1 mark

1

(iii) only some absorbed/amount absorbed
depends on thickness of paper

for 1 mark each

2

(c) 1 → 1/2 → 1/4 → 1/8

for 1 mark

3 half lives/3 × 433

for 1 mark

1299 years

gains 3 marks

3

[8]

2

(a) (i) electron
neutron
proton
nucleus

1 mark for each correct label

4

(ii) H-1 has no neutrons
H-3 has 2 neutrons

more neutrons gets 1 mark

2

(iii) nucleus unstable

2

(b) lead/concrete
lead/concrete needed to stop gamma rays

2

[10]

3 (a) two from:
internal/bodies
thoron
building materials
soil
food
rocks
radon
gamma rays
cosmic rays/outer space

any 2 for 1 mark each

2

(b) only a very small amount of the background
radioactivity comes from nuclear power owtte.

accept any sensible response for 1 mark

1

(c) use G.M. tube/meter/counter or film
'count' higher than or compare with background/normal/control or film is blacker

for 1 mark each

2

(d) more neutrons/different number

gains 1 mark

but I-131 has 4 extra neutrons = 2
or I-131 has 78 neutrons I-127 has 74 (2)

gains 2 marks

2

(e) (i) emits radiation
ionises
molecules
in cells
radiation damages cells/mutation/kills cells
may cause cancer
β /☌/radiation is penetrating
half-life is long enough for damage to be caused

any 4 for 1 mark each (4 from above)

4

(ii) e.g. replace I-127 in body/body cannot tell the difference/causes thyroid cancer/causes cancer (but not if already given in (i))

for 1 mark

1

(iii) **Either** No
half-life = 8 days many half lives have passed/attempts to calculate number of half-lives **or** explains meaning of half-life so very little left/become harmless

for 1 mark each

or Yes half-life = 8 days such a large quantity was released although little left it is still harmful

for 1 mark each

3

[15]

4

(a) 1.
-1

2

for 1 mark each

(b) (i) 19p,
20n,
19e

all correct for 2 marks
2 correct for 1 mark

2

(ii) K40 has an extra neutron/different number of neutrons/
it has more neutrons/21 neutrons

for 1 mark
NOT fewer neutrons

1

(iii) radioactive/unstable nucleus/ nucleus disintegrates/
emits radiation/it has too many neutrons

for 1 mark

1

(iv) calcium/Ca

for 1 mark

1

(v) 1 (e) in outer shell/same number of electrons/outer electron
same distance from the nucleus

for 1 mark

1

(c) (i) Geiger-Muller tube (photographic) film

for 1 mark

1

(ii) cancer, leukaemia, radiation sickness etc.

for 1 mark

1

[10]

5 (i) the nuclei
of hydrogen/smaller atoms
join to make helium/larger atoms

for 1 mark each

3

(ii) the mass of the large nucleus (atom) is less than the mass of the smaller nuclei (atoms)

for 1 mark

mass loss converted into energy or small mass loss given a large amount of energy

for 1 mark

2

[5]

6 (a) 1, 0
X, -l (X = negligible / very small / (1/1840) to (1/2000), but not nothing

2 for 4 correct
1 for 2/3 correct

2

(b) has a nucleus which is positive charge
negative charges (electrons) orbit nucleus

each for 1 mark

3

[5]

7 (a) two half lives

gains 1 mark

but
20 minutes

gains 2 marks

2

(b) alphas will be stopped by skin / air **or** do not penetrate betas and gammas can reach / damage organs / cells

for 1 mark each

2

[4]

8 (a) nucleus positive charge / protons in nucleus electrons / negative charges orbit nucleus

each for 1 mark

3

(b) (i) positive dough repels positive alpha particles **or** 2 positive charges repel forces small

each for 1 mark

2

(ii) large force needed + ves in plum pudding spread out – *may appear in (i)*

positive charge must be concentrated / in nucleus
(ignore references to electrons)

for 1 mark each

3

(c) 1, 0
X,–l (X = negligible / very small/(1/1840) (1/2000),but not nothing)

each row for 1 mark

2

(d) (i) 4

for 1 mark

1

(ii) B and C have the same number of protons / atomic number but different number of neutrons / mass number

each for 1 mark

3

[14]

9 (a) 90

for one mark

1

(b) (i) neutron

for one mark

1

(ii) nucleus

for one mark

1

(iii) electron

for one mark

1

(c) (i) 100

for one mark

1

(ii) 157

for one mark

1

[6]

10 (a) (i) B

for one mark

2

(ii) has a different number of electrons (protons)

for one mark

(b) (i) A and C

for one mark

1

(ii) same number of protons / electrons, same nuclear charge
different number of neutrons / nuclear masses different

for 1 mark each

2

[5]

11 (a) (i) beta and gamma (*any* order)

for one mark

1

(ii) gamma

for one mark

1

(b) (i) particles / atoms / molecules become charged / gain / lose electrons

for one mark

1

(ii) e.g. to kill cancer cells (*allow* any use of alpha, beta or gamma or X^- radiation)

for one mark

1

(c) (i) time taken for no. of atoms / no. of nuclei / mass of U238 / activity to halve – ***not*** radioactivity

or

time taken for count rate to halve

for one mark

1

(ii) atoms with unstable nuclei which emit radiation

(*not* definition of isotope but isotope which is radioactive gets 1 mark)

for 1 mark each

2

(d) (i) 1 / 4 *accept* 25% or 0.25

for one mark

1

(ii) 2 × half life or 2 × 4500 million years (independent of (i))

gains *1 mark*

but

9000 million years ecf only if answer to (i) is $\frac{1}{2}, \frac{1}{8}, \frac{1}{16}$, etc.

gains 2 marks

2

[10]

12 (a) (i) B

for one mark

1

(ii) has 4 electrons / protons others only 3; B has a different no. of electrons / protons - *not* A and C have same no. of protons / electrons

for one mark

1

(b) (i) A and C

for one mark

1

(ii) same no. of protons / electrons different no. of neutrons
or
nuclei have the same charge but different mass

for 1 mark each

2

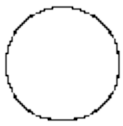
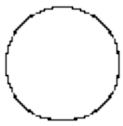
(c) (i) 

(ii) 

(iii) 

for 1 mark each

3

(d) 2p.2n  *allow*  *but not* 

(i.e. no mark if electrons shown)

for one mark

1

[9]

13 (a) the Sun is subject to two balancing forces / 2 forces in equilibrium
the forces are: gravity making it contract **or** inward force due to gravity
and a force due to temperature / heat / energy / radiation pressure making it expand **or** outward force due to temperature / heat / energy / radiation pressure

for 1 mark each

3

(b) Read all the answer first. Stop after 6 marks.

hydrogen / fuel used up owtte the star will expand and become a red giant
it will contract under gravity become a white dwarf
it may explode and become a supernova throwing dust and gas into space
leaving a dense neutron star / black hole

(no mark for contradiction)
any six for 1 mark each

6

[9]

14 (i) 86

1

(ii) 222

1

[2]

15 **Quality of written communication**
The answer to this question requires ideas in good English in a sensible order with correct use of scientific terms. Quality of written communication should be considered in crediting points in the mark scheme

Any **three** from

radon releases (alpha) radiation

accept radon is radioactive

1

(radon **or** radiation causes) harm **or** damage to body **or** cells

accept cause cancer / mutations /
radiation sickness

1

idea that living near radiation over long period will lead to large 'dose' of radiation

radon (is a gas) that can be breathed in

1

[3]

16 beta

1

alpha absorbed by paper

allow beta and alpha
second mark is linked to first

1

or beta absorbed by aluminium allow beta can penetrate paper
or gamma would affect all of film

i.e. cannot obtain second mark unless first mark is correct

[2]

17 (a) radium

accept Ra

1

(b) different numbers of protons

accept one has 91 protons, one has 92
or *Pa has 91 protons, U has 92*
do ***not*** *credit they have different atomic numbers*
reject different numbers of protons and neutrons

1

(c) alpha

1

(d) neutron changes into proton

accept electron lost / beta radiation
accept singular or plural answers

1

[4]

18 any **three** from

max 2 if stages but no explanation

- the star (Sun) expands because
  (inward) gravitational forces no longer balance (outward) force

  accept the star collapses rapidly causing the core temperature to increase and the star to expand
  accept it expands because the forces are unbalanced

- to become a red giant

- when the fusion stops it contracts / cools

  accept (when hydrogen is used up) it collapses under gravity
  accept when fusion stops it contracts and explodes

- to become a white dwarf

  accept to become a supernova / pulsar / neutron star / black hole (only if red giant has exploded)

[3]

19 (a) (i) any **two** from

(matter from) exploded star / supernova

matter so dense / gravity so strong

that electromagnetic radiation / light cannot escape from it

2

(ii) X-rays emitted

1

when gases or matter released from nearby stars spiral into it

1

(b) fusion (of nuclei)

1

of lighter elements / hydrogen helium

1

[6]

20 (a) (i) cannot penetrate aluminium

allow can only pass through air / paper too weak is neutral

1

(ii) gamma rays not affected (by aluminium)

allow <u>all</u> / <u>most</u> (gamma rays) to pass through

too strong is neutral

danger is neutral

1

(b) (i) (nuclei) unstable

1

(ii) causes harm / damage to body / cells

allow radiation sickness

1

detail e.g., causes mutations / causes cancer / damages DNA / damages chromosomes

allow two effects for 2 marks

1

[5]

21 (a) (i) two protons

1

2 neutrons

if neither point gained allow 1 mark for helium nucleus

1

(ii) electron

1

(b) neutron splits (to form proton and electron)

1

[4]

22 (i) 7 **or** 8

1

correct data extracted from graph e.g. takes 8 days to drop from 50 to 25

allow appropriate annotation of graph

1

(ii) long enough to destroy cancer cells

do not accept dangerous unqualified

1

but short enough to minimise damage to surrounding tissues

1

[4]

23 Quality of written communication: One mark for using correct scientific sequence : gravity → fusion → balance

1

any **four** from

- (dust and gas) pulled together by gravity
- (star formed when) it is hot enough
  accept (as mass is pulled together) it gets very hot
- <u>hydrogen</u> (and helium) nuclei <u>fuse</u>
- (these nuclear fusion reactions) release the energy / heat / light (which is radiated by stars)
- energy causes expansion
- gravitational pull is balanced by the expansion (force)

4

[5]

24 (a) (i) two protons

1

2 neutrons
if neither point gained allow 1 mark for helium nucleus

1

(ii) electron

1

(b) neutron splits (to form proton and electron)

1

[4]

25 Quality of written communication

correct use of **three** <u>scientific</u> terms e.g. radiation / α **or** β **or** γ / cells / ionisation / mutation (not cells or body) / chromosomes / DNA / genes / cancer

1

any **three** from:

(materials emit) radiation

named type of radiation (α **or** β **or** γ)

damage / harm / kill

dangerous is neutral

cells / chromosomes / DNA / genes

cancer

mutations

ionisation

gloves or glass absorb radiation / prevent radiation reaching body or cells

3

[4]

26 (a) protons

1

protons

accept electrons

1

neutrons

1

(b) protons

reject mass

1

[4]

27 2 weeks

if answer is incorrect 2 gains two marks weeks gains one mark
half of 68 or 34 gains one mark / allow working shown on graph

[3]

28 (i) (strontium-90)
beta rays <u>partly</u> absorbed by aluminium

*accept gamma rays not absorbed **and** alpha all absorbed*

if phosphorus -32 then one mark max for beta ray explanation

1

long half life means it can be <u>used for a long time</u>

1

(ii) (technetium-99)
(gamma) rays will <u>pass out</u> of body / less likely to be absorbed

accept (gamma) less damaging or alpha / beta will damage cells if cobalt -60 then one mark max for gamma ray explanation

1

short half life means it will <u>not affect body over a long period</u>

1

[4]

29 neutron becomes proton / neutron emits electron / neutron emits beta particle

gains proton neutral

[1]

30 (a) materials produced when earlier stars exploded

accept the Sun is a second generation star

accept formed from nebulae

1

(b) **Quality of written communication:**
1 mark for correct sequencing balanced forces → expansion → contraction / explosion

1

any **five** from

gravity pulling matter together

accept idea that a star is very massive so its force of gravity is very strong

high temperatures that create expansion forces

nuclear fusion releases energy that causes the very high temperatures

these forces balance

star expands greatly

since expansion is greater than gravity

accept fuel runs out

forms a red giant

give no further marks if red giant → white dwarf, red dwarf etc

collapses inwards and explodes outwards

called a supernova

neutron star may form

leaves a small, dense object (a black hole)

accept nothing can escape from it

5

[7]

31 (a) sensible scales

full use of y axis

1

completely accurate plotting

1

a smooth curve going through all bar one of the points

do not accept a dot-to-dot graph if two parts shown for curves
accept the more correct

1

at least one line or a clear mark showing how to obtain the half life from the graph and obtaining between 13 and 15

at the bottom of the page cross or ticks in the order of the mark scheme

1

(b) (i) to let the beta particles get through

*accept must be there to let the radiation through **or** if thick they may be stopped*

1

(ii) alpha particles would be stopped by the glass **or** cannot penetrate glass

do not accept alphas are weak

1

(c) (i) it will give more counts per minute for a small quantity **or** it does not last so long so may not be as dangerous

accept answers in terms of 5 years assume it refers appropriately

1

(ii) it will not be there long enough to act as a tracer **or** it could cause radiation damage as all its activity will be in the first place it enters the system

accept answer in terms of 5 seconds

accept not there long enough to work assume it refers appropriately

1

[8]

32 any **one** of

* between (stage) 2 and (stage) 3
* (in) the main sequence
* (in) the main stable period
* (it is a) yellow dwarf

[1]

33 (a) (i) alpha particles cannot penetrate covering

do not credit any answer not relating to film badge or its case

1

(ii) film gets fogged **or** blackened

accept film gets exposed

*do not credit film changes colour **or** goes white **or** blotchy*

1

(b) (i) any **one** from

may cause cancer may damage cells **or** cell nucleii causes mutations
changes DNA

*accept (causes) burns **or** kills cells*

1

(ii) any **two** from

treating cancers
tracers in body
sterilising instruments **or** bandages

accept two descriptions of named treatments, eg thyroid check and circulation monitoring

*accept is a source of X-rays, eg for dentistry **or** taking X-rays of bones*

2

(c) calculation that 1000 is 3 half lives on

8000 → 4000 → 2000 → 1000

1

time elapsed is 3 × half life = 31.8 hr

award both marks for 31.8 hr or 1 day 7.8 hr with no working shown

1

[7]

34 (a) (i) and (ii) in any order

1

(i) alpha

accept Greek symbol (α)

1

He^{2+} **or** $^{4}_{2}He$

1

(ii) beta

*accept Greek symbol (β) **or** electron*

1

e^{-} or $^{0}_{-1}e$

mass and automatic numbers are not required

accept e

1

(b) (i) alpha

accept symbol

1

(ii) decreases

then stops (entirely) **or** after a few cm

accept stops because α can only travel a few cm in air

1

(c) it's gamma

*accept its not ionising **or** it is not charged **or** it's not* a *or β because a spark counter only measures α or β*

1

[8]

35 (a) at least **6** points correctly plotted

gains 1 mark

(to better than half a square) **but all** points correctly plotted

gains 2 marks

2

any **line** graph related to plotted points;
point (3,29) discounted;
best fit smooth curve

each for 1 mark

3

(b) radiation decreases with time

gains 1 mark

but decreases quickly at first then more slowly

gains 2 marks

but *idea that* it (about) halves every 2 weeks **or** half-life is (about) 2 weeks

gains 3 marks

3

[8]

36 (a) *evidence of conclusion* 4 × 1.007825 **or** 4.0313

each gain 1 mark

based on use of data that there is a (very small) loss of mass
or 0.0276 **but** a loss of mass of 0.0276 **for every helium atom or** 0.69%/0.7%

gains 3 marks

3

(b) *idea that* loss of mass results in release of energy

gains 1 mark

but small loss of mass results in huge energy release

gains 2 marks

2

[5]

37 (a) one relevant point correctly plotted

gains 1 mark

but two relevant points correctly plotted

gains 2 marks

but three relevant points correctly plotted

gains 3 marks

curved line drawn accurately through the points

for 1 further mark

4

(b) age of igneous rock = 400 ± 100 million years

1

(c) sandstone is a sedimentary rock

for 1 mark

there is likely to be some lead–207 present
or from the rocks from which the sandstone was formed

for 1 mark

(*allow* ^{207}Pb may not have come from this ^{235}U)

2

[7]

38 (a) it use $E = mc^2$

mass in kg i.e. $0.001 \times \frac{0.7}{100}$

each gains 1 mark

but 000007

gains 2 marks

2.1×10^3

gains 3 marks

evidence of 0.000007

mass in kg (i.e. 0.0007 **or** 0.7/100000)

each gains 1 mark

squaring the speed of light

but 6.3×10^{11} *(credit alternative ways of stating this)*

gains 3 marks

units J/joule

for 1 further mark

(N.B credit kJ, MJ, GJ but check power of 10 for full credit)

4

(b) (i) *idea that* the bigger the mass the shorter the life

gains 1 mark

but *idea that* decrease in life is much more than proportional to increase in mass

or more than proportional to $mass^2$

gains 2 marks

2

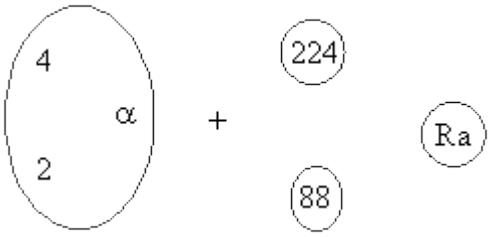
(ii) *ideas that*:
greater mass means greater **core** temperature/pressure
greater core temperature/pressure means greater rate of fusion
increase in mass produces a proportionally much greater increase in the rate of fusion

each for 1 mark

3

[9]

39 (a)

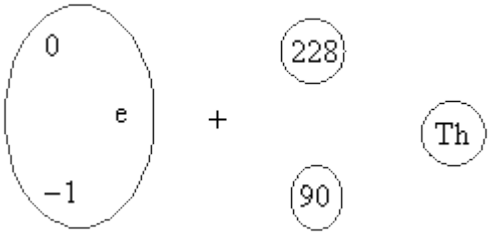


[Accept He^{2+} for α]

each ◯ *for 1 mark*

4

(b)



[Accept β for e]

each ◯ *for 1 mark*

4

(c) (i)

beta/ β		alpha/ α
alpha/ α		beta/ β
beta/ β	but	alpha/ α
alpha/ α		beta/ β

[i.e. consistent for 1; consistent and correct for 2]

gains 2 marks

2

(ii) *ideas that*

- many thorium atoms because they take so long to decay*
- (many lead atoms because) the thorium has been decaying for so long/for billions of years

or (because) the rock is so/very/billions of years of years old

- many lead atoms because this is the stable end product [of the decay series]
- few atoms of other isotopes because they decay so quickly*

[*N.B. credit answers in terms of half-life]

any three for 1 mark each

3

[13]

40

(a) evidence of $\frac{7350}{15}$

gains 1 mark

but

490

gains 2 marks

but

4900

gains 3 marks

units cm^3

for 1 further mark

4

(b) some of radioactive solution gets into cells/body organs
some of radioactive solution gets into urine (in the kidney)
the radioactive solution becomes less radioactive during the test
variability in readings

in any order for 1 mark each

3

(c) *ideas that*

- won't lose (too) much radioactivity during the test
- won't stay radioactive/harm cells for too long after test is over

for 1 mark each

2

[9]

41

- 4
- 9

each for 1 mark

[2]

42 (a) c/gamma

- because more penetrating
- so can reach/damage cells from outside body/through skin

but

a/alpha

- does more damage/more likely to cause cancer
- can only do this if <u>inside</u> the body/cells

each • for 1 mark
[credit same ideas expressed conversely]

4

(b)
- must emit alpha / a radiation
- *idea that* half-life must be just long enough to kill cancer cells

each for 1 mark
[do not credit simply short half-life]
(allow 'must be liquid / in solution)

2

(c) *evidence of repeated halving* ***then***

$\frac{n}{}$ ´ 3.6

gains 1 mark

but

answer in range
22 – 25.2 days
(ie >6 and up to 7 half lives)

gains 2 marks

2

[8]

43 ideas that

- formed from dust/gases
- pulled together by gravity
- massive so very large gravitational forces (pulling inwards)
- hydrogen → helium / fusion releases energy [not fission or just 'nuclear']
- high temperature creates high pressure (pushing outwards)
- long period when forces balance
- then expands → red giant / red star
- then contracts to (dense) white dwarf / white star

[credit if massive enough / more massive than sun, red giant → supernova → (very dense) neutron star but do not accept w.r.t. Sun itself]

[The whole of the (non bracketed part of) each idea must be present in some appropriate for in of words for each mark to be credited. To gain more than a single mark ideas must also be in correct sequence and/or appropriately related.]

any six 1 mark each

[6]

44 A β / beta
B γ / gamma
C α / alpha

for 1 mark each

[3]

45 (a) indication (in writing or on graph) of finding point where radiation is halved (e.g. to 24 [from an initial 48]) and relating to the time difference between the two points

gains 1 mark

but

4.2-4.8*

(*i.e. in this range, including extremes)

gains 2 marks

units billions of years

for 1 mark

3

(b) ¾ **or** 75%

[allow ecf from (a)]

for 1 mark

1

(c) (i) *idea that* the intermediate nuclides are relatively short-lived

for 1 mark

1

(ii) *idea that* ¼ has decayed **or** ¾ remains

gains 1 mark

but

read graph for radiation level of 36 (stated or shown on graph itself)

gains 2 marks

but

1.6-1.8* (billion years)

(* i.e. in this range, including extremes)

gains 3 marks

3

[8]

46 (i) (fast moving) electrons (from the nucleus)
(*allow* negatively charged particles)

for 1 mark

1

(ii) protactinium has one neutron fewer
protactinium has one proton more
(*credit* has different numbers of neutrons / protons *with one mark*)

for 1 mark each

2

[3]